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*Occupational
Health Branch*

Occupational Health in Ontario

Volume 4, Number 4, October 1983

Notification of New Chemical Agents in Ontario

Indoor Air Quality and CO_2 Levels

Female Capacity for Physical Work

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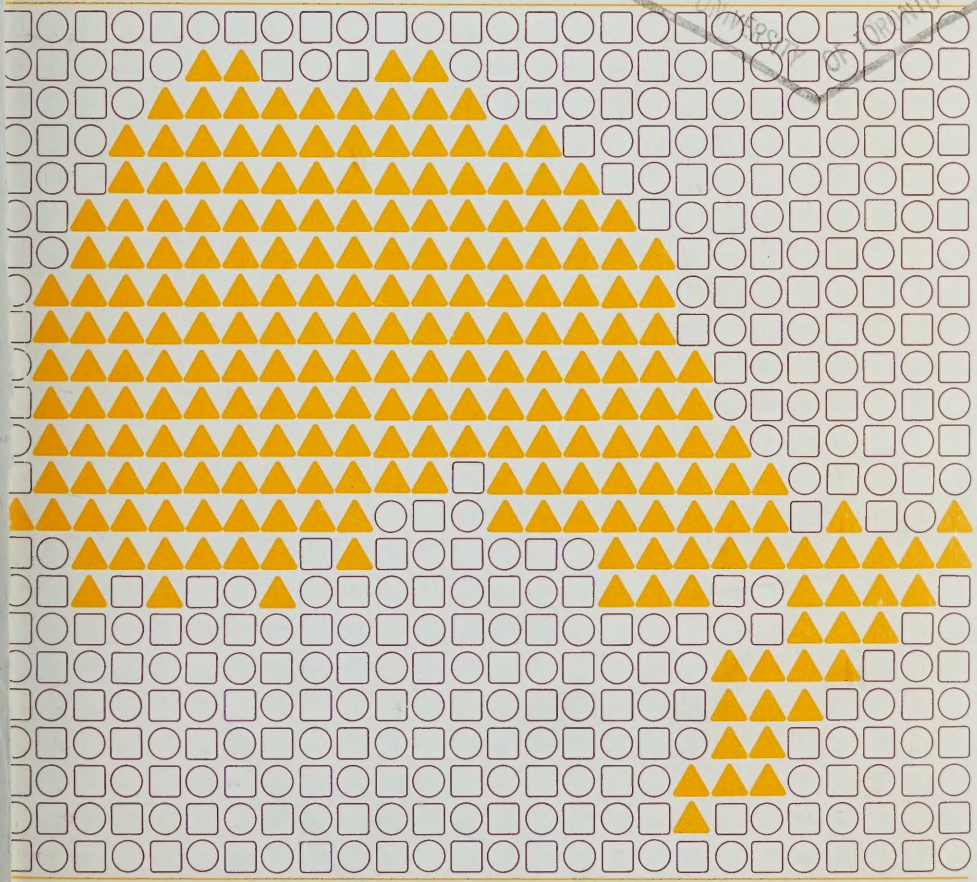

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Occupational Health in Ontario

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2. Department of Health and Social Security, Notes on the diagnoses of occupational diseases. Rev ed. London: HMSO., 1972.
3. Gamble JF, and Battigelli MC. Epidemiology. In: Clayton GD and Clayton FE. eds. Patty's industrial hygiene and toxicology. New York: McGraw Hill, 1978: Vol 1; 113-116.

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Notification of New Chemical Agents in Ontario

Summary

Section 21 of the Ontario Health and Safety Act, including the procedural requirements, is discussed. A summary of toxicological testing is presented.

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Prior to the introduction of the *Occupational Health and Safety Act*, which took effect October 1, 1979, no provincial legislation existed in Ontario for the notification or investigation of new chemicals.

The present Act had its beginning in 1976, following the publication, that year, of the Report of the Royal Commission on the Health and Safety of Workers in Mines. The Ham Commission, as it was known, was a governmental commission set up in 1974 to make recommendations regarding occupational health and safety in the mining industry in Ontario. The Ham Commission report made many progressive recommendations and highlighted the need to control chemical hazards. This resulted in interim legislation called the *Employees Health and Safety Act, 1976*, which created the Occupational Health and Safety Division of the Ministry of Labour and culminated in the *Occupational Health and Safety Act, 1978*. However, the Ham Commission report itself made no recommendations to require the reporting of new chemicals.

In the same year as the Ham Commission report was published, Canadian federal legislation regarding the reporting of new chemicals was enacted as the *Environmental Contaminants Act*, or E.C. Act. The federal legislation requires the reporting of chemical compounds newly manufactured or imported in excess of 500 kg, and requires a person responsible for such manufacturing or importation to notify the federal minister specifically of 'any information in his possession respecting any danger to human health or the environment posed by the compound.' However, toxicological evaluations conducted under the federal legislation examine chemicals from the point of view of public health and safety and hazards to the environment. They do not specifically address workplace situations where workers are ordinarily subjected to higher exposures from selective routes than they are from the general environment.

The workplace is the primary environment where new chemicals are introduced and must be controlled. There was therefore a need to require the reporting of new chemicals to the provincial Ministry of Labour. This

is the rationale for the incorporation of section 21, which requires such notification, into the Ontario Act. Section 21 is, of course, only one of several means to control toxic substances. Basic to the Act is the internal responsibility system, whereby management and workers address health and safety issues, with ministry staff checking their compliance with the Act and regulations. The Act specifically provides that in workplaces where the number of workers exceeds 20 there must be a health and safety committee with worker representation. The health and safety representative's duty is to inspect the workplace, identify hazards and make recommendations to the employer. Under the Act, subject to certain exceptions, a worker has the right to refuse to work if he believes working conditions are hazardous. In cases where issues are not resolved representatives of the Occupational Health and Safety Division may be called in to serve as consultants. Through the Act the minister is empowered to control chemical substances or any other agents known to be toxic to human health. These substances are known as 'designated substances' and are subject to specific regulations in Ontario. There already exist specific regulations respecting lead, mercury, vinyl chloride, coke oven emissions, asbestos and isocyanates, and regulations respecting noise and silica have been prepared. Notice of Intent to regulate arsenic, acrylonitrile, benzene, cadmium, chromium, formaldehyde, ethylene oxide and styrene has been published.

Section 21 is therefore consistent with the overall concept of the Act, which relies on the internal responsibility system in the workplace to identify not only known hazards, but also new agents. However, we must not lose sight of the fact that the force behind the legislative mandate is the raised public consciousness and the consciousness of the worker with respect to chemical hazards. Workers and management alike generally realize that we are living in the post-thalidomide and post-DBCP era. It is accepted that new chemicals must be sufficiently screened before being introduced. According to another section of the Act (section 20), in the event that an agent, including a new agent, is likely to endanger the health of a worker, a director may prohibit, limit, or subject the use of the agent to such conditions as he or she specifies. Before this can be done the director must, of course, have sufficient information on the new agent, which he or she may require under the actual notification section, section 21. The Director is an inspector appointed under the Act as a Director of the

Occupational Health and Safety Division of the Ministry. The Occupational Health Branch is one branch of the Occupational Health and Safety Division responsible for administration of the Act, and in the context of section 21, the director refers to the Director of the Occupational Health Branch.

In Ontario, in the application of section 21, we have studied and attempted to harmonize our procedural guidelines and policies with Canadian federal guidelines and with other countries and organizations such as the Organization for Economic Cooperation and Development, the Sixth Amendment of the European Economic Community and the Toxic Substances Control Act in the U.S.

The size of our task may be roughly estimated. In the U.S., perhaps 1,000 new chemicals are introduced into commercial production each year. Since many of our new agents in Ontario are imports, principally from the U.S., but also from Europe, perhaps no more than 50 of these will be imported into Ontario each year.

Present Situation Regarding Section 21

To date some 61 chemical agents have been reported under section 21. The director meets his obligations in assessing notifications by assigning these to a toxicologist within the Occupational Health Branch for review. The toxicologist, after reviewing the initial submission and after obtaining the consent of the director, informs the company that further specific reports and assessments are required or, alternatively, that no further reports or assessments are required. Usually, further reports and assessments are required, and a dialogue ensues between the toxicologist reviewing the notification and the company. In most instances good quality material is submitted, but it is often insufficient to allow a proper assessment. A few case histories will serve to illustrate:

Case I. A notification is submitted by Company X including information of extensive testing of a new agent, which indicates that the new agent is a highly toxic compound. An order mandating specific protective equipment based on the toxicity of the agent is issued by the director. This is an example of the use of section 20 to subject the use of the agent to conditions specified by the director.

Case II. A notification is submitted by Company Y. Company Y, however, initially declines to reveal chemical names or formulae for the new agent or its

starting materials without written assurances of confidentiality of proprietary information. Assurances are given so that the information, without which the notification is incomplete, is submitted by the company. An order by the director requiring the report is not necessary.

Case III. Company Z submits a notification of a water clarification chemical, but insufficient information is given. Company Z is requested to provide further reports and assessments. The company replies that full data have previously been supplied to the Ontario Ministry of the Environment. With the express approval of Company Z the data are obtained from the appropriate official in the Ministry of the Environment.

Case IV. Company P submits a notification for its product, which is a mixture. Company P's product is produced by a local small formulating company, Company Q, which does not have an MSDS for the active, and most toxic, ingredient. The ingredient in question is supplied by a third company, Company O, which imports it from Europe. Eventually, a translation of the European label is obtained, but a North American style MSDS is still to be formulated.

Case V. A company inquired whether an agent exempted from the TSCA Inventory, which we have adopted as a baseline, should be exempted from notification in Ontario. We replied that although we have adopted the EPA Inventory, June 1980 edition as a baseline inventory, we have not automatically adopted the TSCA Act and all the exemptions under that Act. This is because U.S. legislation to cover these exemptions is different from Canadian federal and provincial legislation. We therefore require notification of the agent when it is imported into Ontario.

The above cases serve to illustrate some of the difficulties encountered in evaluating notifications. In many instances difficulties could be avoided if:

1. the original manufacturer, distributor, supplier or importer is always the first to notify the ministry;
2. the original manufacturer, distributor, supplier or importer ensures that he has adequate information in English, and in a North American format, before he begins manufacturing, distributing, supplying or importing;

3. companies do not attempt to use the research and development exception where the agent is being sold or used commercially for certain purposes.

Present Procedural Requirements

Section 21 states:

'1) Except for purposes of research and development, no person shall,
a) manufacture;
b) distribute; or
c) supply,
for commercial or industrial use in a workplace any new biological or chemical agent or combination of such agents unless he first submits to a Director notice in writing . . . . . the notice shall include the ingredients of such new agents or combination of agents and their common or generic name or names and the composition and properties thereof.

2) Where in the opinion of the Director, which opinion shall be made promptly, the introduction of the new biological or chemical agent or combination of such agents referred to in subsection 1 may endanger the health or safety of the workers in a workplace, the Director shall require the manufacturer, distributor or supplier . . . to provide, at the expense of the manufacturer, distributor or supplier, a report or assessment . . . .'

Thus manufacturers, distributors or suppliers of a new agent in Ontario must submit a notice to the director. This notice must include chemical structure, composition of a mixture, chemical and physical properties and, where a hazard to the health or safety of workers may exist, further reports and assessments, i.e. results of toxicological tests are required by the director. Section 21 exempts new agents used for research and development purposes; ordinarily, the practice has been that the director is notified when such agents go into pilot plant operation, and marketing plans are contemplated.

In Ontario we have adopted the June 1980 edition of the Environmental Protection Agency (EPA) Inventory as a baseline inventory. This inventory is also known as the TSCA Inventory since it was established under the U.S. Toxic Substance Control Act. The EPA Inventory was adopted because it was felt that to compile a separate baseline inventory for Ontario was not justified as many of the 50,000 chemical substances listed in the inventory would be common to both the U.S. and Ontario. Future additions to the Ontario Inventory may be made up of those substances not included

in the EPA Inventory, but which were in use in Ontario prior to October 1, 1979, as well as those notifiable under section 21.

A substance may be new in two ways. An agent is new in Ontario if it was not in use in Ontario prior to October 1, 1979 (the date the Act became effective) and if it is not contained in the EPA (TSCA) Inventory (June 1980 edition). There has been some confusion regarding the definition of a new agent since in Section 21 (3) the language used is as follows: ' ''new biological or chemical agent or combination of such agents'' means any such agent or combination of such agents other than those used in one or more workplaces *and* included in an inventory compiled or adopted by the Ministry.' Bill 53 has been introduced into the House and provides, in part, that the 'and' in the above sentence becomes 'or'. In this way companies will be more certain that if a chemical is in the EPA Inventory, then it is not a new agent. We are currently defining new agents using the 'or'. Another reason for the introduction of Bill 53 is that many mixtures of old known agents may not be listed in the EPA Inventory as mixtures, i.e. they have never previously been combined. However, no new chemical is formed upon mixing known agents, and industry would be burdened with reporting new mixtures of known compounds when the toxicity of the mixture can simply be related to the toxicity of the known components. Bill 53 would make such simple mixtures non-reportable. However, it should be realized that the proposed change in the law places more responsibility on industry to know when a new agent has been formed in a mixture or when the toxicity of a mixture is unexpectedly different from the components. In these cases the mixture should still be reported. Bill 53 had its first reading on June 2, 1983.

Data requirements for notification consist of information on chemical structure, the composition of a mixture, its chemical and physical properties and sufficient information on the toxicological properties to assess the hazard to the health and safety of workers. Obviously, knowledge of the industrial process and the manner in which workers may be exposed must be an integral part of the assessment.

The provision of this type of information by companies to governmental organizations often causes company concern about whether proprietary information will be kept confidential. When the notifier wants the report to be handled in strict confidence, the information should be submitted to the Director of the Occupational Health

Branch. When it is received, it is kept in a locked cabinet in the director's office. A single copy is made, and this is kept in locked files for use by a toxicologist. Thus the ministry has already adopted the policy of limited access to confidential data as the principal means of maintaining confidentiality. When confidential files become voluminous consideration will be given to using computers to store the data. Appropriate security will be enforced to restrict access.

Companies' submissions may also include non-confidential material, such as safety data sheets. All confidential information should be clearly identified so that security can be maintained. Sometimes information labelled confidential is available from the open literature, for example, *Toxline*, and this raises the issue of justification of confidentiality. If a need arises, such as the question of the public interest, the notifier may be required by the director to justify confidential handling. Except where release of information is required by law, all requests for information from the ministry will be referred to the notifying company.

The cost of testing a new agent is sometimes very great and the manufacturing or developing company (Company A) has the primary responsibility for both testing and bearing the associated costs. If, however, Company A has failed to notify the ministry of a new agent, but has sold a consignment of the agent to a customer company (Company B) for use in the manufacture of Company B's product, it then becomes the responsibility of Company B to notify the ministry, but not necessarily to pay for the testing. Whether Company A has or has not carried out toxicological testing, Company A is required at this point to submit further reports and assessments.

However, workers in both companies are exposed to the new agent. It is possible for Company B, in purchasing a new agent from Company A, to protect itself from Company A's failure to notify by making provisions in the purchasing contract to cover both the notification requirements under the section and any related costs.

There is still a tendency for some companies not to notify, i.e. to hold back and wait. The ministry does not require any more data than companies themselves should want to know about new products in order to safeguard the health and safety of their employees, so there is no justification for companies to withhold notification.

Toxicology of New Agents

In order to perform a complete assessment of the toxicology it is almost always mandatory to know the chemical formula and structure of the agent(s) in question. This is because it is sometimes possible, from a knowledge of chemical structure and by analogy with the toxicity of known agents, to make a prediction concerning the type of toxicity or the mutagenic capability associated with a new chemical (the 'structure-activity' relationship). In the case of a mixture, it is necessary to know, at least within a certain range or as closely as it can be known, its percentage composition.

Ordinarily, rat oral LD_{50}s give an initial estimate of toxicity. Since the chemical agents are new, usually little human toxicity data is available, and animal data have to be relied upon.

Workers in industry may be exposed by several routes. Exposure may occur by skin or eye contact, inhalation and, rarely, oral ingestion. Because skin exposure is common in industry some data on skin absorption, irritation and/or sensitization are needed for a proper assessment. Likewise, as inhalation is a common route of exposure in industry, it is sometimes desirable to measure the LD_{50}.

Inhalation determinations require the use of a specialized inhalation chamber, and therefore tests of inhalation toxicity are more difficult and expensive than oral or skin toxicity tests. In order for exposure by inhalation to occur, the chemical must be either a gas, a vapour of a volatile liquid or an aerosol containing particles of respirable size. The majority of particles larger than 10 μ do not penetrate beyond the nasopharynx and the tracheobronchial region. Particles with a diameter between 10 μ and 3 μ reach the alveolar ducts, and those with diameters between 3 μ and 0.5 μ reach the alveolus and may be retained. Particles smaller than 0.5 μ usually remain suspended in air by Brownian motion, and these are exhaled. Therefore, the necessity for inhalation tests will depend on: 1) the initial oral toxicity determination, 2) the physical form of the agent, i.e. whether particles of respirable size are present, and 3) the manner in which workers may be exposed.

The following Table contains a summary of commonly-employed toxicological tests. Included in the initial group of tests would be the acute toxicological tests and perhaps a short-term mutagenicity test, such as the Ames test. The necessity for further testing, i.e. subchronic and chronic testing, depends not only on the results of acute testing, but also on the potential of

the agent for mutagenicity or carcinogenicity as judged from its chemical structure, the type of worker exposure, etc. In essence, requirements for testing each new agent are considered individually in the context in which it is to be used, i.e. manufactured, distributed or supplied in Ontario. A set of 'Guidelines for the Notice of Intent to Manufacture Distribute or Supply . . .' for the reporting of new agents has been prepared.* These guidelines are almost all-inclusive and list almost all possible tests. It is not required that these guidelines be completed in full for every notification, but they serve as an indication to the companies of the type of information that may be required. Guidance is provided to companies concerning which tests are sufficient to complete the notification process.

Summary of Toxicological Testing

Acute Testing	Observations	Minimum Species	Exposure Period
Acute Oral Toxicity	LD_{50}, MG/KG	Rat	14 Days
Acute Inhalation Toxicity	LC_{50}, MG M^3 or PPM	Rat	4 Hours
Acute Dermal Toxicity	LD_{50}, MG/KG	Rabbit	24 Hours
Eye Irritation	Subjective Scoring System	Rabbit	3 Days
Primary Skin Irritation	Subjective Scoring System	Rabbit or Guinea Pig	Variable
Dermal Sensitization	Subjective Scoring System	Guinea Pig	Treatment and Rechallenge
Subchronic Testing			
Subacute Toxicity	Mortality, Bodyweight Changes, Diet Consumption, Hematology, and Clinical Chemistry Measurement	Rat + ? Species	At least 30 Days up to 90 Days
Chronic Testing			
Chronic Oral Toxicity (Occasionally Inhalational Toxicity)	Observations as for Subchronic	Rat & Usually Dog	Up to 2 Years
Mutagenicity	Ames Test, Other Short-Term Tests	*S. Typhimurium*, Mammalian Cell Culture, Others	Variable
Pharmacokinetics	Studies on Bioaccumulation, Metabolism, Tissue Distribution	Usually Rat + ? Species	Variable
Carcinogenicity	Pathological Examination Animals During and at End of 2-Year Chronic Toxicity Testing	Rat & Usually Dog	At least 2 Years
Teratogenicity	3-Phase Reproduction Study ± (3 Generation Test)	Rat, Rabbit (Rat)	Dependent on Phase Reproduction Studied

*Guidelines are available from the Director, Occupational Health Branch, on request.

Conclusion

When the ministry has accumulated sufficient notifications, the Ontario Inventory may be updated. This will be an aid to companies because they will then know prior to initiating a notification process what has already been reported in Ontario. Also, industry (specifically the CCPA) has indicated that it would be desirable for them to assemble a list of chemicals not in the TSCA Inventory, but which were in use in Ontario prior to October 1, 1979, for the use of their member companies. If made available to the ministry, these chemicals could then be added to the Ontario Inventory.

The passage of Bill 53 will remove the burdensome reporting by industry of mixtures containing no new agents.

Résumé

Discussion de l'article 21 de la loi sur la santé et la sécurité au travail de l'Ontario, ainsi que des règles de procédure. Présentation d'un sommaire sur les essais toxicologiques.

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Indoor Air Quality and CO_2 Levels

Summary

Materials present in a commercial building may present a hazard to the health of the occupants. Ventilation is important for the control of these materials and for the comfort of the occupants. Standards established by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) are commonly used in North America when investigating occupant complaints in commercial buildings. The normal closed-circuit ventilation systems in office buildings are dependent on the addition of fresh outside air to the circuit and the removal of equivalent quantities of recirculated air. The fresh outside air serves to prevent the accumulation of odours and cigarette smoke and materials associated with office equipment such as photocopy, duplicating and blueprint machines, computers and video-terminals.

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Introduction

Dilution with outside air is an important factor in the ventilation of office buildings. This point has received considerable attention by ASHRAE in recent years and several standards have been issued. In the early 1900s, fresh air levels of 30 cfm per occupant were commonly required, and in the 1930s, this level dropped to 10 cfm per occupant. ASHRAE became active in this area in the 1960s and the current minimum is 5 cfm per occupant. (See Table 1). It is well-recognized, therefore, that the addition of fresh outside air to a closed-circuit building ventilation system is essential to provide sufficient oxygen for normal respiration, to dilute contaminants within occupied spaces, to control infiltration in pressurized occupied spaces and to regulate thermal loads. There are two opposing factors on the matter of adding fresh air to ventilation systems. The one concern is with energy conservation and the minimum addition of outside air, whereas the hygiene consultant's concern is with the comfort and health of the building occupants, which requires the optimum balance of fresh and recirculated air. The reduction of fresh air in the ventilation system will result in occupant discomfort and complaints of 'stuffiness, drowsiness, tiredness, eye irritation, nausea, stale air and lack of oxygen'. The symptoms experienced could be related to many things, and the lack of fresh air in the ventilation of a building is a contributing factor. As the addition of fresh air to the ventilation system is decreased, occupant complaints tend to increase. However, the symptoms experienced by occupants of a building with reduced fresh air in the ventilation system are not imaginary; they are real, and the Ministry of Labour has investigated numerous complaints of this nature.

The usual concern of building occupants is 'lack of oxygen'. This, of course, is not a factor in the origin of these complaints. The oxygen content of ground-level air is about 20.9 per cent by volume. Problems with oxygen deficiency do not materialize until the levels drop to about 16 per cent by volume, or a deficiency of 4.9 per cent. This is equivalent to a deficiency of 49,000

ppm, which would require significant quantities of foreign substances to deplete the oxygen to a level at which health problems are experienced. (See Table 2).

We have found, however, that the levels of carbon dioxide in an office building are related to the frequency of occupant complaints. As the carbon dioxide levels increase from the 330 ppm normally present in the atmosphere, complaints begin to materialize. This increase in the normal carbon dioxide level arises from human respiration, tobacco smoke, combustion processes, etc. Increased carbon dioxide levels indicate insufficient fresh air addition to the ventilation circuit. Hence, measurements for carbon dioxide levels in office buildings provide an indirect evaluation of the ratio of fresh air to recirculated air in the system. Carbon dioxide levels

Table 1

Dates	ASHRAE Guidelines
1900s	30 CFM per occupant
1930s	10 CFM per occupant
1960s	5 CFM per occupant

Table 2

Response of Man to the Inhalation of Atmospheres Deficient in Oxygen

Oxygen Vol. (%)	Symptons or Phenomena
16-20	No symptons Normal air content
12-16	Breathing and pulse rate increased, muscular co-ordination slightly disturbed
10-14	Consciousness continues, emotional upsets, abnormal fatigue upon exertion, disturbed respiration
6-10	Nausea and vomiting, inability to move freely, loss of consciousness may occur; may collapse and, although aware of circumstances, be unable to move or cry out
Below 6	Convulsive movements, gasping respiration; respiration stops and a few minutes later heart action ceases

Source
Patty's Industrial Hygiene and Toxicology, 3rd Revised Edition
Edited by: George D. Clayton and Florence P. Clayton

below 600 ppm are not generally associated with occupant complaints. There may be some complaints if the carbon dioxide levels are in the 600 to 800 ppm range, and in the 800 to 1000 ppm range the complaints are more prevalent. Carbon dioxide levels over 1000 ppm are associated with widespread occupant complaints. (See Table 3).

Carbon dioxide measurements combined with measurements of thermal conditions and air distribution have been used by the Ministry of Labour for many years to investigate complaints of indoor air quality. It is important, of course, that all other factors are investigated to ensure that the source of the problem is not related to emissions from office equipment or to entrainment of exterior pollutants in the fresh air supply of the ventilation circuit.

Table 3

Carbon Dioxide (PPM)	Comments
Less than 600	Adequate fresh air
600-800	There may be occasional complaints, particularly if the air temperature rises
800-1,000	Complaints are more prevalent
1,000	Insufficient make-up air, complaints are general

Case Histories

One situation encountered a few years ago involved the Toronto Stock Exchange. A young man fainted on the Exchange Floor. He was taken to the building exterior (Bay Street) where he quickly recovered. In the interim, several other occupants complained of dizziness, headaches and nausea. These symptoms disappeared when the people left the building and breathed fresh air. The Exchange was shut down shortly thereafter and the Ministry of Labour was contacted. A hygiene consultant was sent to the Exchange to investigate this incident.

Since the building is close to the Occupational Health Hygiene Service's main office on University Avenue, the consultant was able to conduct an investigation shortly after the Exchange had been shut down. The preliminary investigation eliminated the presence of any typical pollutants, such as natural gas, methane gas or internally-generated emissions. The carbon monoxide

level, at 25 ppm, was somewhat elevated; however, it was not sufficient to cause the probems encountered by these occupants.

Measurements for carbon dioxide indicated levels of 1,200 to 1,500 ppm, and temperature measurements revealed the temperatures at the 'floor level' were slightly higher than the recommended values outlined in he ASHRAE Comfort Chart. The fan mix chamber was then inspected and it was noted that the louvres controlling the addition of fresh air to the ventilation circuit were shut down to the minimum. Furthermore, the building maintenance personnel were unaware of the volume of fresh air entering the mix chamber at this louvre setting or any other setting. In an attempt to rapidly reverse the situation, the fresh-air louvres were fully opened and the ventilation system was run with 100 per cent fresh air. The carbon dioxide levels were re-checked after about one hour, and while there was a drop to about 1,000 ppm, conditions at 'floor level' still appeared to be stuffy and only marginally cooler.

The air distribution to the Exchange Floor was then investigated. This was somewhat difficult as the ceiling height is about 35 to 40 feet above the trading floor. However, it was noted that the air supply to the trading floor was a split-flow system. Part of the air was directed to air-supply vents located at floor level at the periphery of the room near the trading telephones. The other section of the air flow was through air vents at the periphery, about 25 feet above the floor level. The return-air vents were located in the ceiling. Further investigation revealed that the major portion of the air supply had been directed to the upper air-supply vents, and that the diffuser vanes of the air-supply vents were directed toward the ceiling, resulting in an obvious short circuit of the supply air. In summary, the findings of our investigation were:

1) there were between 150 to 200 people on the Exchange trading floor at the time of the incident;

2) smoking was allowed;

3) the activity on the trading floor, as described by the media, was hectic;

4) work pressures on the occupants were likely quite high;

5) the temperature of the trading floor was above the recommended maximum of the ASHRAE Comfort Chart, (72° - 77°F);

6) the levels of carbon dioxide were measured at 1,200 to 1,500 ppm, suggesting inadequate addition of fresh air to the ventilation circuit;

7) the distribution of supply air at the trading floor level had been cut back; and,

8) the distribution of supply air at the upper level was improperly directed toward the return air vents.

This incident was an extreme situation in that an occupant of the building collapsed; the activity and pressures on the occupants were higher than in most commercial buildings; and the ventilation was completely out-of-alignment. The outcome of ths incident was favourable. The split airflow was balanced, the upper air-supply diffusers were directed downward to the trading floor, and the fresh-air supply louvres were set so that the carbon dioxide levels at the trading floor level were at 500 ppm in the morning, rising to a maximum of 700 ppm in the late afternoon (3 p.m.). The increased fresh air in the ventilation circuit also resulted in a regulated temperature within the range of the ASHRAE Comfort Chart.

Another situation involved the offices of a Toronto television station. The complaints were of stuffy stale air and lack of oxygen; in addition, occupants located in the basement offices at the north end of the building experienced severe headaches in the late afternoon. The ventilation system was controlled by a rather impressive on-site computer. The computer regulated the air supply to the various floors at a pre-set minimum and compensated, as required, on a temperature basis. The computer was equipped with a memory bank to store individual floor and area measurements of temperature, humidity and air flow. This information was retained on hardcopy printout, and the building management was able to produce records for the past year. In addition, the computer was equipped with a video display that was capable of displaying line drawings of the building's ventilation system illustrating the code network. Our investigation revealed:

1) peripheral offices had been installed on each floor and the ventilation design was for an open-floor concept;

2) room dividers had been used extensively in the core area of each floor to section off office areas;

3) the number of occupants per floor in the core areas was about 25 per cent higher than the recommended maximum, based on the floor space suggested per occupant; hence, overcrowding,

4) many of the window registers in the peripheral offices were blocked with masking tape, books, magazines or cardboard posters;

5) some of the ceiling air-supply diffusers were either totally or partially blocked with cardboard and masking tape;

6) the occupants in the peripheral offices generally ate lunches in their offices, contributing to the odour load of the building;

7) adjustable thermostats located at various positions on each floor allowed temperature adjustments by the occupants to suit their preferences;

8) the ventilation system was on a reduced supply cycle in the evening from 6 p.m. to 7 a.m., whereas the occupants worked irregular hours;

9) the occupants were faced with critical deadlines; and

10) there was a high number of cigarette, cigar and pipe smokers.

In effect, the floors occupied by the workers of this television station had been altered to a point where the original airflow design was totally modified and was unable to provide adequate comfort ventilation for the occupants.

The basement was not originally designed for office space, but, due to station expansions, it was taken over as a studio area. The air circulation was originally designed for minimal cirulation, which, when combined with the construction of closed studios, resulted in cubicles with very little air movement. In addition, the fresh-air intake for the building ventilation system ran from ground level to the top of the building on the north-west corner. At some stage after the building had been erected, a two-storey parking garage was constructed at the north-west corner of the building, closing off the lower section of the fresh air supply to the basement ventilation system. The supply of fresh air was via the garage and contained automobile fumes, including carbon monoxide. Measureable quantities were detected in the morning from 8 a.m. to 9 a.m., and higher quantities at 4.30 p.m. to 5 p.m. when the

majority of occupants left the building. The problem was more noticeable in the colder weather when, of course, people tend to allow their vehicles to idle for several minutes to warm up. The contamination of the fresh air supply to the ventilation circuit with carbon monoxide, and an airflow set on a reduced cycle was, no doubt, the cause of the headaches experienced by these workers. Correction of the situation involved a complete exclusion of the air intake at the garage level and a minor modification to obtain the supply from levels above the second floor of the garage. The quantity of air supply to the basement was also increased.

Complaints from occupants of commercial buildings often occur during the seasonal changeover from heating to air-conditioning, or vice versa. Invariably, there is a hot or cold spell before the changeover occurs, and both the temperature and humidity in offices increase or decrease to levels well outside the comfort zone of the ASHRAE Comfort Chart. Systems with humidity control have an advantage in this situation since the combination of high humidity and high temperature increases the discomfort factor. In many cases the addition of fresh air to the system is reduced or shut down as this supply air has a marked influence on the condition of the recirculated air.

Recommendations

The preceding discussion indicates that a hygienist, while investigating a building environment because of complaints such as stuffiness, drowsiness, nausea, eye irritation, lack of oxygen and stale air, should follow the procedure as outlined below:

1) determine the type of ventilation, i.e. closed system versus openable windows,
2) if a closed system, check for oxygen content of the air, which must exceed 18 per cent,
3) check for CO, which normally will be less than 5 ppm,
4) check for CO_2 content;
5) if the CO_2 level is below 600 ppm, look for some other contaminant causing the health-related complaints, e.g., ozone generated from photocopying machines;

6) if the CO_2 level is between 600 ppm and 1,000 ppm, recommend increase in fresh air supply to bring the level down to 600 ppm or lower;

7) if the CO_2 level is above 1,000 ppm, arrange to increase the fresh air supply immediately.

Résumé

Les matériaux présents dans un bâtiment commercial peuvent présenter des dangers pour la santé des occupants. La ventilation est importante pour le contrôle de ces matériaux et pour le confort des occupants. Le confort des occupants est généralement une notion subjective et personnelle. En Amérique du Nord, on suit généralement les normes établies par l'ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers) lors des enquêtes menées à la suite de plaintes déposées par les occupants d'un bâtiment commercial. Le système de ventilation normal en circuit fermé des bâtiments administratifs dépend de l'addition d'air frais venant de l'extérieur contrebalancée par l'élimination de quantités équivalentes d'air circulant déjà dans le circuit. L'air frais de l'extérieur sert à empêcher l'accumulation d'odeurs, de fumée de cigarettes et de matières provenant de l'équipement de bureau comme les machines à photocopier, à reproduire et à tirer des bleus, les ordinateurs et les écrans vidéo.

John Vander Doelen, M.Sc.

Female Capacity for Physical Work

Summary

This paper explores the capabilities of females to perform physically demanding work. While there are some differences in physical work capacity that favour men over women as a group, females, on an individual basis, appear to have potential capabilities equal to those of males of the same age, size and approximate body composition. Until employers are aware of this, the attempts by women to gain employment in physically demanding jobs will be affected.

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Introduction

The existence of equal opportunity of employment legislation has made a number of jobs that require physical exertion available to women. Currently, little scientific evidence exists to help us determine whether or not females are physically capable of performing the duties that some of these jobs require. When examining the evidence that does exist, care must be taken in the interpretation of whether there truly is a sex-attributable difference in physical work performance. For example, do female muscle fibres contract differently than male muscle fibres or are observed differences the result of muscle size, training and many other factors? This distinction is important when attempting to determine if a woman is suitable for a specific job. If an object of given weight must be lifted, the total force output capability of the muscle is more important than the fact that a female muscle fibre can exert the same force as a male muscle fibre. On the other hand, for tasks that require submaximal force output, it is important to know that female muscle may be as resistant to fatigue as male muscle. This paper will cover the areas of basic anthropometry, muscular strength and endurance, aerobic work capacity and heat tolerance of females. The information comes from studies that have sampled the general population, examined female athletes and used physical training programs to increase the physical work capacity of females.

Anthropometry

This section will briefly review some of the structural differences that exist between males and females. These represent trends in the population, but individual variability does cause some differences between the sexes to disappear or reverse themselves.

The average male is taller and weighs more than the average female. These differences start to occur during the adolescent growth period. Structural differences in addition to height and weight also exist. Males tend to have broader shoulders and narrower hips than females.

Their leg length relative to body length is also greater than females. The arms of males are consistently longer than the arms of females.

Differences in body composition also occur between the sexes. Females have somewhat more adipose tissue at all ages, while males have more skeletal muscle. The adipose tissue to body mass ratio can be reduced for both females and males by active physical training.[1] Also, appropriate physical training can increase the size of muscles for both sexes, but the degree of hypertrophy (enlargement) will normally be greater in males for a given amount of strength development.[2]

Muscular Strength and Endurance

The relationship between muscle strength capacities of men and women is a research topic that has been under investigation since the early 1900s. In reviewing the literature, Hettinger[3] supports the contention that population values for general muscle strength in women is about two-thirds that of men. However, Chaffin[4] shows evidence to doubt percentages as high as 65-70 per cent. Chaffin maintains that the lifting strength of a woman, compared to that of a man, is less than reported in earlier studies.

A review of numerous research papers[5] that primarily sampled college males and females suggests that there is no consistent relationship when comparing relative strength between males and females. The differences tend to be specific to the muscle groups or body part involved. Women's measurements for upper extremity strength range from 35 to 79 per cent of men's, with an average mean percentage of 55.8 per cent. The strengths in the lower extremities of women, compared to men, average 71.9 per cent, with a range of 57 to 86 per cent. Trunk strength measurements revealed that women averaged 63.8 per cent of men, with a range of 37 to 70 per cent. Since there is large variability for these strength measures between subjects, Laubach[5] concludes that the emphasis on reporting female strength should be re-focused on the broad range of strength scores rather than on any single mean figure. Because of the broad range of scores for both males and females there is an overlap of the two groups where some females are stronger than some males.

The values reported above for comparative strength are not valid indicators of the potential strength of a particular female. The studies did not standardize body size or physical fitness and thus are biased against

females. Wilmore[6] has reported that the differences between males and females in lower body strength disappeared when strength was expressed relative to fat free (lean) body weight. This technique allows for standardization based on the amount of muscle the person has. Given this finding, he suggests that the quality of muscles (contractile properties and ability to exert force) is similar for the two sexes. Wilmore[7] feels that the strength differences are related to the use of the muscles and that the leg muscles of females are used to a similar extent as the legs of males. In other words, the legs are in an equivalent state of physical training.

In summary, it appears that there is no sex difference in the quality of muscle but rather that strength is a function of the use of the muscle (i.e. trained state) and the mass of the muscle.

Endurance

Muscular endurance can be defined as the ability of a muscle to maintain a particular level of work. It is a function of energy delivery, energy usage and waste product removal from the muscle. Very little information exists at present on the muscular endurance capabilities of females as determined by direct measurement. However, a number of significant differences in the biochemical composition of skeletal muscle of males and females have been observed. Nygaard[8] has found lower levels of glycolytic enzymes (anaerobic lactic energy system) in sedentary females than in sedentary males of the same age. She has found the same situation for enzymes of the anaerobic alactic energy system. These systems affect how energy is developed in the muscle. This information suggests that women will have less muscular endurance than males at workloads of high intensity. Unfortunately, it is not clear whether this is a true sex difference or merely a reflection of differences in the state of fitness or training between the two groups. Training will result in similar adaptational increases of the enzymes involved in both of these energy delivery systems for both sexes.[9]

Aerobic Work Capacity

Aerobic work capacity refers to the maximum capability of an individual to utilize oxygen during physical exertion. It is the aerobic energy system that provides the majority of the fuel for work of a continuous prolonged nature (longer than six minutes). If the job is to be performed for the whole day, then the individual will

have to rely on the aerobic system. Although there are many contributors to the capacity of this system there are some major factors that exert strong influences over the maximum capacity. Some of the more important factors are age, heart size, red blood cell count and trained state. It is unclear at this point whether or not there is also a factor of sex that influences maximum aerobic capacity independently of these other factors. If the major factors are equal, then females may very well have the same maximum capacity as males.

When individuals increase their energy expenditure from resting levels, adjustments in the cardiovascular and respiratory systems occur. These adjustments allow the new energy demands to be met. The next section will outline some of the adjustments that do occur and highlight the areas of comparison between males and females.

Respiratory System

The respiratory system responds to an increase in physical work output by increasing the volume of air that is inhaled and exhaled each minute. The number of breaths per minute increases as well as the depth of each breath. Ventilation may increase from a value of 6 L/min at rest to 150 L/min in maximal exercise.

Lung volumes are related to body size and vary approximately as the cube of a linear dimension such as body height. The lung volumes of females are 10 per cent smaller than those of males, even after the differences in body size have been considered.[10] This may be the result of lower physical activity levels for adolescent females than for adolescent males, as some research has shown that training may affect lung size at this age.[11] The maximal voluntary ventilation is a measurement of the total amount of air that the individual can breathe in and out in one minute. This capability has an important influence on the maximal aerobic work capacity. The range of values for normal 25-year-old males is 100 to 180 L/min while for females the range is 70 to 120 L/min.[10] Comparison of these population values is complicated by the fact that they are not standardized for body size or trained state. The males are most certainly larger and are likely in a greater trained state than the females.

Cardiovascular System

The primary response of the cardiovascular system to an increase in level of work is to increase the amount of blood that the heart pumps per minute. The amount of blood that can be pumped is affected by body size and trained state. At rest, cardiac output is approximately 4.6 L/min and can increase to 24.1 and 18.5 L/min for untrained males and females respectively.[12] No values standardized for body size could be found to compare males and females. The increase in cardiac output is accomplished by two means; heart rate increases as does the amount of blood that is expelled per beat (stroke volume). Increases in stroke volume occur up to a heart rate of 110 beats per min.[12] As exercise intensity is increased, heart rate continues to increase while stroke volume stays the same until maximum work capacity is reached.

The extraction of oxygen from the blood, by the muscles, increases progressively as the intensity of exercise is increased, but eventually maximal extraction is reached. There is also a redistribution of blood flow from the non-working muscles and intestinal area to the working muscles, which increases the availability of oxygen.

Females tend to have smaller hearts than do males[13] and this affects the maximum cardiac output. Heart size is greatly influenced by body size and trained state, which likely accounts for much of the observed population differences. Females do tend to have a maximum heart rate that is 10 per cent greater than men[14] and this does have some effect in offsetting the influence that a smaller heart has on maximum cardiac output. Also, women have less hemoglobin per volume of blood and thus have a reduced ability to carry oxygen. This will make it more difficult to supply oxygen to the working tissues during maximal work. However, increasing trained state results in increased total body hemoglobin levels and larger blood volumes.[15]

Maximal Work Capacity

There is no doubt that the maximal aerobic capacity of the 'average' woman is less than that of the 'average' man.[16,17,18] A 15 to 20 per cent differential has been found in normal populations.[16,18] Because of the influence of many factors, such as size, age and fitness, this research finding is not very helpful when one is trying to determine if a work task can be done by a woman.

Observed differences in aerobic capacity are not necessarily the result of gender. In Canada and the United States young female swimmers and track athletes have maximal aerobic capacities equal to, or greater than, those of males of the same age who are not athletes.[19] Even within the normal population there is considerable variability within the sexes and an overlap of maximum aerobic capacity values for the more fit women and the less fit men. Hermansen and Andersen[18] found that 76 per cent of Norwegian female students overlapped 47 per cent of the male students. A group of Canadian physical education students had an overlap of 32 per cent between maximum aerobic capacity of males and females.[20]

When attempting to determine if 'true' sex differences in maximum oxygen uptake occur, it is important to choose a proper system of reporting the values. This would prevent variables other than sex from confounding an interpretation of the data. Some authors[21,22] have reported that the difference in maximum aerobic power (MVO_2) between the sexes disappears when oxygen uptake is expressed in relation to lean body mass. This technique permits an evaluation of the capabilities of the tissue that is involved in doing work. Davies[21] found that MVO_2 on a bicycle ergometer was related to the volume of the active tissues of the leg (thigh and calf) and not to gender. These findings suggest that 'female' muscle is no different from 'male' muscle in its ability to use oxygen. MacNab[20] could not replicate this finding. Males had greater oxygen uptakes regardless of how they were expressed. This is an area that requires further investigation with adequate research designs before any conclusive statements can be made. Confounding factors such as amount of physical activity and fitness levels must be controlled before it can be determined if true sex differences in maximal aerobic capacity exist.

Submaximal Work

This section will examine whether or not females react in a manner similar to males when performing the same work load. It has been reported that females have a lower oxygen requirement than males for a specific work load, but that this difference disappears if oxygen uptake is expressed as ml/kg/min (millilitres of oxygen/kilogram body weight/minute) versus l/min (litres of oxygen/minute).[17,18] This occurs because tasks that require supporting or moving the body tend to represent a greater work load for males since they generally are

heavier than females. Expressing oxygen uptake merely in l/min does not standardize for this greater work load, but expressing oxygen uptake as ml/kg/min does.

At the same work load, the 'average' woman is usually working at a higher percentage of her maximal aerobic capacity than the 'average' man. If the work load is high enough she is also relying to a greater extent on her anaerobic energy delivery system. This results in a lactate level that is greater than for the 'average' male.[17,18] Elevated lactate levels can make it more difficult to continue the work. Astrand[12] found that during a submaximal workload of 600 kpm women had an average heart rate of 151 beats/min, whereas men had a heart rate of 106. The higher heart rate is a compensation for the smaller stroke volume of women's generally smaller hearts. It should be noted, though, that physical fitness again exerts a strong influence on this difference between the sexes. Hermansen and Andersen[18] found that heart rates of female athletes were equal to, or lower than, the rates of male students at all submaximal work loads.

The menstrual cycle acts as a source of confusion as it relates to physical activity for females. Although some medical opinion suggests that intense physical competition should be avoided during the first two days of the menstrual period, most experts agree that physical activity should not be avoided during any phase of the menstrual cycle in healthy females. Gamberale *et al*[23] compared performance of two submaximal work tasks during different phases of the menstrual cycle. They found that there were no real differences in cardio-respiratory adaptation, measured on the basis of heart rate and oxygen uptake, even though the study was comprised of women with menstrual distress. Jurkowski *et al*[24] provide further support for the position that aerobic performance and cardio-respiratory adaptation to exercise are not influenced by the phase of the menstrual cycle. They found no difference in heart rate, ventilation, oxygen uptake or carbon dioxide output between the two phases of the menstrual cycle during light and heavy exercise. They did find that lactate levels were higher for heavy work (90 per cent of maximum) done during the follicular phase, six to nine days after the onset of menstruation, than for the luteal phase, six to nine days after ovulation. Motivation may be important in the performance of heavy work during this time since elevated lactate levels can make it more difficult to continue.

High intensity submaximal work does present a physiological challenge to females, but research demonstrates that they are capable of making adjustments to continue the work. These take the form of higher heart rates and greater reliance on energy sources that do not require oxygen.

Present information suggests very strongly that the specific requirements of the work task and the characteristics of the individual must be considered when one is attempting to match an employee to a physical task. While the majority of males are larger than females and many men have oxygen uptake capabilities exceeding those of females, there are large areas of overlap between the sexes. Some females are capable of performing high levels of aerobic work for sustained periods of time. Wardle and Gloss[25] report that non-athletic females were able to complete an experimental eight-hour work day at an average energy expenditure of 277 kcal/hr. This is a high energy expenditure and is classified as heavy work.[26] Cement mixing and pushing a wheelbarrow with a 100 kg load are examples of work tasks that require such energy expenditures.

Heat Tolerance

When individuals work or exercise in a hot environment, all of their normal responses to the physical work are magnified. The elevated ambient temperature requires that additional physiologic adjustments occur so that metabolic heat can be released. The extent of the adjustments depend on many factors, both individual and environmental. Research has attempted to determine whether females elicit the same magnitude of response to heat stress as males. This question is more complex than it might at first appear. There do appear to be a few 'true' sex differences, but often these are overwhelmed by factors such as body size, state of acclimatization and physical fitness.

Body size affects the ability of an individual to tolerate heat. In the case of moderate heat stress, small individuals are better able to achieve thermal equilibrium because of the high ratio of surface area to body mass. Where ambient temperatures are greater than skin temperature, a high surface area to body mass ratio is a disadvantage. This condition results in a forced heat gain from the environment, which is poorly tolerated by small persons since their temperature is more easily raised due to their low thermal mass.[27] The temperature

of a large mass will not rise as quickly as a small mass when exposed to the same temperature. Per cent body fat also affects response to heat, albeit in an indirect way. Heat transport from the centre of the body to the skin is dependent on the cardiovascular system and is independent of skinfold thickness.[28] However, extra weight does increase the metabolic cost of any task that involves lifting the body (stepping or walking uphill). This results in more body heat being generated and thus more heat that needs to be dissipated.

Regular exposure to a hot environment stimulates adjustments in the body so that the heat strain can be reduced. This acclimatization can be attained in six to 12 days.[29] Females show the same pattern and time course of acclimatization as males.[30] Increases in physical fitness also result in similar changes to reduce the stress of elevated temperature environments. The changes with acclimatization and fitness improvement are very similar to the often reported differences between males and females in heat tolerance. This fact contains a clue for explaining why average males and females differ in heat tolerance. Many of the studies that report sex differences in heat tolerance have not controlled for the factors of fitness and acclimatization. Another source of controversy over sex-related differences may be whether the hot environment is humid or dry.

Evaporative cooling is a crucial factor in human thermoregulation. Much of the disagreement over limitations in female heat tolerance centres around possible differences in the sweat mechanism of males and females. Postulated differences that have been proposed are: higher temperature threshold before sweating starts, a lower sweat rate and variability in sweat suppression.

Recent research[31,32] compared female response to heat with that of men. These studies have attempted to control for the factors that make interpretation of research results describing sex differences difficult. Fitness level, state of acclimatization and body size were all considered in the design of the studies and the interpretation of the data. The finding of most interest was that

> '. . . no differences occurred in evaporative weight losses, sweating rates or % body weight losses in the heat. It was concluded that (1) women accustomed to exercise in a desert climate are able to substantially increase their sweating response and (2) that acclimatized male and female subjects of similar aerobic capacity have comparable responses to rest and exercise in a desert environment.' [32]

Frye and Kaymon[33] and Shapiro *et al*[31] support these findings for dry heat, but found that females sweat less under conditions of heat with high humidity. This sweat suppression by females is an advantage since sweating is an ineffective cooling technique under conditions of high humidity. A low sweat rate has the advantage of conserving body water. Indicators of physiologic strain were lower for females under high humidity situations because they benefited from their higher surface area to mass ratio due to their smaller size.

In summary, there does not appear to be a true 'sex difference' for heat tolerance that results in substantial benefit for either males or females. Factors such as maximum work capacity or fitness, state of acclimatization and body size should be considered whenever an employer is selecting an individual to work in a hot environment. Although in practice, the 'average' male tends to have greater capacities than the 'average' female in all of these, one must often be reminded that there is a large overlap in capacity between the sexes for these parameters.

Conclusions

This paper has attempted to compare the characteristics of males and females that influence the ability to do physically demanding work. Although research information is incomplete, there does not appear to be an overwhelming influence of sex on the ability of an individual to perform hard physical work. To a great extent, a male and a female of the same age and build appear to have the same potential for doing physical work. The maximal work capacity that either can be or has been attained is influenced by trained state, personal genetic endowment and state of acclimatization. Many females have a lower trained state and acclimatization level because of social pressures that influence their activity levels.

In conclusion, just as employers cannot assume that any male is capable of doing a physically demanding task, they should not assume that all females are incapable of performing that task. The women who are at present employed in jobs requiring strenuous physical exertion provide support for the position that females are capable of doing this type of work.

Résumé

Ce document explore les aptitudes des femmes à exécuter des travaux demandant des efforts physiques. Il existe des différences en faveur des hommes en tant que groupe en ce qui concerne les travaux physiques, mais prises individuellement, les femmes semblent avoir des possibilités identiques à celles des hommes du même âge, de même taille et de robustesse à peu près semblable. Tant que les employeurs ne le sauront pas, les efforts que feront les femmes pour chercher un emploi exigeant une certaine vigueur physique en seront affectés.

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Book Review

Encyclopaedia of Occupational Health and Safety Volume 1 A-K (Third Edition) International Labour Office, Geneva

The title describes the book well in that it is a reference book that provides information on all aspects of occupational health and safety. This is the first of two volumes of the third edition of this work and contains 1,176 pages (compared to 753 pages in the first volume of the second edition) covering about 500 subjects of wide scope.

Illustrated with hundreds of photographs, diagrams and line drawings, the book discusses manufacturing processes, toxic substances, dusts, mineral fibres, allergenic substances, carcinogenic substances and occupational diseases. Each subject has been treated with thoroughness, including recommendations for preventive measures and, where necessary, subjects have been dealt with under more than one heading, e.g., asbestos, and asbestosis and asbestos (mesothelioma and lung cancer). Each chapter has its own list of bibliographical references – up to the date of publication.

This edition has effectively rendered the second edition obsolete.

Overall, the book is an excellent, comprehensive, well-printed and profusely illustrated reference work of the subjects covered (A-K). Needless to say, the second volume is eagerly awaited.

G.S. Rajhans

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Coming Events

November 1-4, 1983	Joint Conference on Occupational Health, New Orleans, Louisiana.
November 9-11, 1983	Canadian National Congress of Occupational Medicine, Westin Hotel, Toronto, Ontario, Canada.
December 12-15, 1983	International Seminar on Methods of Monitoring Human Exposure to Carcinogenic and Mutagenic Agents, Espoo, Finland.
May 7-9, 1984	International Conference on Occupational Ergonomics, Harbourcastle Hilton Hotel, Toronto, Canada. Details from R.D.G. Webb, Technical Chairman, Toronto '84, P.O. Box 1085, Station 'B', Rexdale, Ontario, Canada M9V 2B3 Tel. (416) 675-2235.
May 22-25, 1984	ARBO 84 – International Trade Fair for Safety, Health and Welfare at Work – RAI Amsterdam. Details from RAI Gebouw bv, Europaplein, 1078 GZ, Amsterdam.
July 10-12, 1984	SOM Annual Provincial Meeting, York, England.
August 20-24, 1984	Third International Conference on Indoor Air Quality and Climate – Stockholm, Sweden. Details from Mr. P.R. Warren, Building Research Station, Garston, Watford, WD2 7JR. Tel. 09273 74040.
September 9-14, 1984	21st International Congress on Occupational Health, Dublin, Ireland. Details from Dr. C.S. Macnamara, Organizing Secretary, XXI International Congress on Occupational Health, 44 Northumberland Road, Dublin 4, Ireland.
December 3-5, 1984	Inter-Noise 84 – 13th International Conference on Noise Control Engineering – Honolulu. Details from the Inter-Noise 84 Secretariat, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603, USA.

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